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## A PRELIMINARY STUDY OF THE BEHAVIOR OF MENTAL IMAGES.

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Most of the treatises on the topic of imagery have been grounded on the isolation and classification of the material, and have possessed all the advantages and disadvantages of this method. The facts comprised in the term mental or associational type are a contribution of the very greatest importance. To determine the special sense channel in which a subject's mental processes tend to flow is now a recognized prerequisite to psychological work, since it gives a constant known quantity, so to speak, in the estimation of all results obtained from him. The chief criticism to which the method is liable is that its conclusions are based on mass results, hence too general and lacking in that concreteness which the subject of images can justifiably demand.

The present study<sup>1</sup> is an attempt to supplement the classificatory results by an examination of particular images, if not in their functional relations, at least *in situ*. It was our desire at first to make an exact register of the behavior of the image as regards the time intervals of clearness, indistinctness, disappearance, etc., and in this way obtain an index of its persistence in consciousness. We soon found it impossible, however, to make such a record, as the slightest attention given by the subject to the work of registration, even with the most delicate instruments, resulted in the immediate and permanent loss of the image. Actual trial proved the method not only impossible but also undesirable as the changes in the appearance of the image were found to depend upon a set of circumstances quite as important as the changes themselves and entirely too complex and variable to reduce to exactitude. So it was thought that the accumulation and comparison of introspective results, obtained under test conditions, would afford the best means of approaching the image in its actual relations. This, of course, required subjects who were exceptionally well trained in methods of introspection. As to type, one was strongly visual, another auditory-motor, and a third visual-motor, so that there

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<sup>1</sup> This investigation was undertaken at the suggestion of Dr. Sanford, and part of the work was carried on with his assistance.

was sufficient diversity to keep the conclusions from the error of being based on one-sided results. All of them had had several years of training in psychological work, and were used only after trial had demonstrated their expertness in introspection. Incidentally, it is surprising how many supposedly well trained experimentalists are found deficient in this requirement, and the insistence by Professor Titchener upon the fact that the experiment is only an arrangement of conditions to assist the introspection, may be considered most timely.

The method was to ascertain as nearly as possible the exact behavior of the image during a certain interval of time, which after trial was fixed at ten seconds.

#### VISUAL IMAGES.

Visual images are by far the clearest and most independent, and in consequence, have offered the most fruitful field for the investigation of the general subject. For the study of related problems, like those of memory and association, that material would naturally be chosen which was least involved with other factors, and which would show in the most direct way the result to be attained. The consequence is that images from other sense departments have been largely ignored in the literature, and relatively too much prominence given to those of a visual nature. Fechner's description<sup>1</sup> of his own visual images is given solely for the purpose of distinguishing them from after images, but is, notwithstanding, the best account of their characteristics yet presented. The chief distinctions, he tells us, between after images, on the one hand, and memory and fancy images, on the other, are that the former appear only with a feeling of receptivity, in connection with a certain sense impression, and independently of voluntary effort and association of ideas; and depart, also, relatively to the immediately preceding sense impression, and independently of voluntary effort. Memory and fancy images arise with a feeling of greater or less spontaneity, a longer time after the preceding sense impression, partly involuntarily through the association of ideas, partly voluntarily, and can be varied and banished in the same way. He describes his memory and fancy images further as seeming to lack corporeality, as washed out and indefinite. He cannot obtain clear sharp boundaries and can produce only the most familiar memory images of objects that are daily before his eyes. He cannot hold the memory image more than a short while. It must be renewed if observed longer. If he tries repeatedly to call it up, the attention or production activity becomes blunted. This is not at all a blunting of recall (mem-

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<sup>1</sup> *Elemente der Psychophysik*, II, p. 469 ff; 1889.

ory activity), since he is not hindered from calling up another memory image just as clear, and when the attention goes back to the first image, it can be produced with original clearness. This holds of closely related images, as two figures in the same photograph, or two portraits in the same room. If these are used too continuously, the attention blunts for both, but can turn to a third and back again in the same way. In no case can he place objects in the memory field in other relations to each other than as corresponding to the forms of actual observation, and his fancy cannot operate with its creations outside these limits. Thus he cannot represent a man full face and in profile at the same time. Another result is that he can succeed more easily in arousing memory images with open than with closed eyes. The field is more limited but still relatively clearer. To do this he must entirely withdraw the attention from without, and can succeed better when the eyes are turned toward the floor. It is as if with complete closing of the eyes, the lightstuff, of which the images are woven, is lacking; as if the dark field is more disturbing for its perception than the soft daylight. Memory images, unlike after images, are possessed of perspective, and can be made to appear in any direction desired. He can pass from one memory image to another quickly, almost simultaneously, with a feeling of continuity; can also pass from after image to memory image quickly, but the continuity is broken. The attention must be abstracted from the after image in order to get the memory image. The only reference he makes to the relation of images in the different sense departments is that when we pass from one to the other, there is a definite, not to be described but easily reproduced, *feeling* of the changed direction, which we can liken to a differently localized tension, as from eye to ear.

Reference has been made to Fechner's work at length because it is the nearest approach in the literature to the object of the present study. Galton's chapter on "Mental Imagery"<sup>1</sup> is chiefly of a statistical and descriptive nature. He considers the question of visualization from the point of view of its prevalence, and finds it generally deficient with men of science, strong with artists, vivid with children and primitive peoples, and varying somewhat with nationality. The work, while of the greatest value in a general way, can hardly be relied upon in its discussion of particular points, and shows throughout the deficiency of not having subjected its material to exact experimental conditions.

Among later works may be mentioned those of Lay<sup>2</sup> and

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<sup>1</sup>Inquiries into Human Faculty.

<sup>2</sup>Psych. Rev. Mon. Sup. VII: Mental Imagery.

Bentley.<sup>1</sup> The former is almost entirely a study of types, based upon results obtained from students, artists and himself. The latter is an investigation of the visual memory image with reference to its qualitative fidelity and the effect of varying intervals of time upon it. The materials considered are brightnesses and colors, and the work is of great value from the standpoint of both method and results. It suffers only from the exceedingly limited range of its experimentation. There is included a most suggestive section on the genetic function of the memory image.

We have used the terms *mental image* and *memory image* as referring to the same set of phenomena, and perhaps it is necessary to justify this procedure by explaining in what sense they are interchangeable. Memory image has come to mean, specifically, one in which is reproduced with more or less completeness the original observation, with all the factors necessary to make it determinate. It is a process in which recall and recognition play an important part. The meaning of mental image is not very definitely fixed by usage, but with some the term characterizes that large group of images whose location in space and time has been lost. The question is chiefly one of familiarity. We do not call the image aroused by the word *horse* a memory image, because horses have been seen under so many sets of circumstances that no one stands out in particular. It is valuable for some purposes to preserve this distinction, but it really rests on a superficial analysis. The word *horse* is, in ordinary usage, little more than a word, and if any image is aroused, it is in most cases general, shadowy, symbolic and of only an instant's duration. If it is required that a definite image be produced and held when the word is called, it will be found that a very definite associative complex will come up in connection with it. This is either a particular situation from past experience or a composite of such situations. If the name of a certain building with which the subject is familiar, is called, the resulting memory image has reference, not necessarily to a particular occasion of observation, but to many such occasions, and is, really, in its turn, a composite. So the mental image is hardly one in which particular reference is lost, but in which the possibility of particular reference is manifold. So under the conditions of our experiments, which necessitated in every case the production of a definite image, it would serve no purpose to keep the distinction rigid.

In the following tests, with the exception of the card series, drawn figures were used instead of call words. The purpose in this was to keep the associative complex as much as possible

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<sup>1</sup> *Am. J. Psych.*, XI, 1: The Memory Image.

under control. The subject was permitted to look at the figure for some time before the "ready" signal was given, at which he closed his eyes. Five seconds were allowed to elapse between the "ready" and the "now" which marked the beginning of the ten seconds interval, in order that the after image and the memory after image might pass away. A second "now" was used to close the interval, and the introspection was taken as quickly as possible.

(1) *Small black square on white card.*

St. Could not get it in several trials. Some figure would form around it and when he tried to drive it away whole thing would go.

K. Was able to see the black square; seemed to be hollowed out on two of the sides. Then movement of the attention from the square to the four corners of the card. Gray lines came in as diagonals and gave the whole card the appearance of a pyramid truncated at the square. Then came a blank period of about two seconds. Image was vague during remainder of period and only came out in flashes.

(2) *Black square in larger square.*

St. Could get only one side in. Others seemed to be there but not distinct. Spot quite clear.

K. Lines of outer square came first, with blotches or knobs in the corners; lasted about three seconds; very bright and distinct; central square entirely absent except for the vague feel of something there. Then went to square in center and imaged figure as a whole. Not distorted except for the corner spots. Did not notice outline of card.

(3) *Black and two surrounding squares.*

K. Saw outside square first; light yellowish; corners prominent again; lasted about a second. Then started on next square and got the two together. Middle spot still left out; did not appear distinct at any time. Figure did not hang together as one image. After about five seconds whole thing very vague. Corner knobs came on only the outside square; otherwise form not distorted.

(4) *Squares with diagonals added.*

St. Squares much more prominent than spot; two diagonals most distinct. Time of distinctness much greater than time of indistinctness; change very gradual; did not disappear at any time.

K. Whole thing vague. Started on outside lines; vague notion of lines inside; no perspective. Then got feeling of motion in figure waving back and forth. Then black square in center came out very clear. Then vague perspective as looking into hollow. Lines still vague and outlines of hollow not clear but black spot remained so.

The above series seems to warrant these suggestions and conclusions.

(1) It is a matter of the greatest difficulty to get and hold a very simple image like that of a small black square. Neither subject could get it alone in repeated trials. An easy form of the experiment is to place a white dot on a large blackboard, and after looking at it, close the eyes and try to hold it for several seconds. It will be found impossible in most cases.

(2) This leads us to conclude that a certain degree of com-

plexity is necessary in order to make an image continuous. This has an illustration in the second test where subject St could get only one side of the surrounding square, but this was sufficient to make the spot quite clear. A result that was entirely unexpected was the tendency of both subjects in the first test to supplement the lack of complexity in the figure by adding a subjectively created means of holding it. With St, this consisted of surrounding lines, and with K, of diagonals leading from the square to the four corners of the card, and throwing the whole into the perspective of a pyramid truncated at the square. Another interesting fact came out in the black-board experiment. An image of the whole board would first be obtained, and immediately afterward the image of the dot would flash out clearly for an instant. While this was happening, however, the outline of the board would disappear completely. It would seem as if the image itself could produce a memory after image of position, which would persist for a moment after the disappearance of the image. Examination of any of our complex memory images will show that what seems to be an entire picture is really a matter of successive parts, a residue of position running from each into the next so as to give the feeling that they are presented simultaneously.

(3) The tendency to emphasize angles, as seen in the knobs which K placed at the corner of the square, and diagonals which with St took precedence of the rest of the figure, will be discussed later under the schematism of the image.

(4) The last two tests are remarkable for the diversity of results. When the figure was made more complex by the addition of another square, neither subject could hold the image complete but broke it into parts. K says definitely that it did not hang together as one figure. With St, when the diagonals were added, it became very difficult to get the spot. The opposite was true of K who threw the whole figure into pyramid perspective in which the lines were very vague but the spot very clear. It seems that here we have an indication of the limits of complexity in a plane figure which it is desired to hold as one image. If true, the range from minimum to maximum complexity is a very narrow one. It is, at any rate, evident from these tests that the clearest and most persistent images are those in which the spot stands in close relation to only a line or an angle. The probable difference between this and greater complexity is that the latter requires more time for the play of attention, and in this way the continuity in the perception is broken. The sense of perceptive which K had in the last test seems to be a means of subsuming a complex setting into a simpler one.

(1) *Semicircle.*

St. Able to get it easily, but when tried to hold without losing, brought on a sort of quivering. Direction and size as shown. Clear about two-thirds of time. No tendency to eye movement noticed.

K. Started on left-hand end of image and went around circumference. Figure distorted by bulging out in left quadrant. Slight stop at that point then rest of the way around. Saw the figure complete after about two seconds; then lost; afterward returned as whole for an instant. Did not notice eye movement.

(2) *Circle.*

St. More fluctuation than in semi-circle between distinctness and indistinctness; much harder to hold. Not all parts clear at same time. When made circumference object of attention, decided tendency to move eyes around. If on center, no tendency to eye movement, but circumference not clear in all parts. Attention moves either across or around. Some tendency to distort by making vertical diameter longer. Fluctuations about a second long.

K. Noticed center point first; then went to left and around. Seemed to get the circumference in pulses. Then got all parts equally distinct but lost center. Figure distorted by becoming smaller and larger. Several blank spells.

(3) *Circle with crossed diameters.*

St. Upper left and lower right segments only ones that came out, so that figure took hour-glass form. No tendency to eye movement.

K. Upper right and lower left sectors came out; really saw spaces without noticing lines. Other two were added on but looked darker. Then let rest go and tried to see circumference; got upper left segment. Then finally got circle complete with indistinct contents; lost idea of being cut up in parts.

(1) The first result of importance in this series is that curved lines are harder to hold than straight ones. The semi-circle could be held complete, though only for a short time, which is undoubtedly due to the straight line forming the diameter. The circle was much more subject to fluctuations, and only a part could be held at one time. The result obtained from St in the circle test is typical of the way in which curved lines are imaged. If attention is given to the center in order to get the whole figure, the circumference becomes indistinct. If the circumference is brought out clearly, it comes in sections following the movement of the eyes which is very perceptible. This latter fact gives a clue to the difficulty, in holding a circle as compared with a straight line. The eyes seem to move easily in following a line even of considerable length, and with much greater difficulty in following a curved line. If the movement is not exact and well-controlled, the result is a distortion of the figure, as in all of K's images of circles. It may be that this difference in the ease of eye movement is carried over into a difference of ease in holding the image.

(2) In the final test, the result is the same with both subjects. The crossed diameters are so prominent in the image that



they shut out the circumference almost entirely by arresting the necessary eye movement. The greater clearness of opposite rather than adjacent spaces, is a fact that comes out in all experiments involving crossed lines. Both this and the joining of the ends by opposite segments is probably due to the attempt to follow out both lines at the same time. This is certainly true with the writer, who finds in addition, that the angle subtended by these segments constantly tends to grow smaller and the lines to run together.

(1) *Blank playing cards.*

St. First was of indefinite white background. Changed into ace of spades; not very distinct. Card was out in front, against gray background; position oblique.

Sr. White background; white card cut off from background by black lines. Black lines became indistinct about three times. By end of period had gone completely.

(2) *Ace of hearts.*

St. White background back of ace and some distance from it. Other images tried to crowd in. Fairly clear ace, a little larger than real. Card some clearer than blank.

Sr. Got card in oblique position on wall; heart in middle. First, a confused red, then changed to ace of spades, then came out clear red. The spade was small and ordinary size, not large and elaborate, and pointed down like the heart. Clear at end of period.

(3) *King of hearts.*

St. Fairly distinct, but kept oscillating. No outline to card; only heart and king visible. King seemed pretty clear; color same as real.

Sr. Confused at first. Card straight: king double with sceptre, might have been the knave, not the queen. No heart visible. Figure darkened and grew confused toward the end.

(4) *Straight flush from ace of hearts.*

St. Could see about two at a time in row: rest mere outline of hand. Passed down the row in this way.

Sr. After a time of confusion saw them spread out with ace at left and others in order. Ace was clear and remained so all through. Picture cards confused and could not be distinguished. Nothing definite about the others; shaded off into darkness; even the number could not certainly be fixed. Still trying to get the other cards, starting from ace which remained clear, when time ended. Colors in picture cards fairly clear.

The facts shown in the first two tests are the production of the blank card by cutting off a part of the gray background with black lines, and the tendency of closely related images to crowd in. This is one of the very few instances in these experiments where an antagonism of images was apparent, and here it is along a natural path of association. The third test shows that where a figure of great complexity stands in conjunction with another of little complexity, the latter is liable to be entirely neglected. With St, the outline of the card was lost,

and with Sr, the heart did not come in. The image of the straight flush affords a good study in the relation of extent and detail. St could hold the outline of the hand and pass along it seeing two cards at the time. Sr could hold the outline and ace clearly, but the rest remained confused.

(1) *Letter A.*

St. Had some trouble in getting it. Hard to hold. Could not get natural size, seemed much larger. White spaces clearer than lines. Black was grayish. Was not defined clearly as letter, openings were too large.

St. More nearly natural size. Fluctuation in clearness very rapid; caught himself moving head in sort of rhythm corresponding to clearness. Did not repeat letter verbally. Noticed no tendency to run to other images during fall in clearness.

K. At first quite clear cut image as it is with white center left out; lasted about two seconds; broken by negative after image. Then again more distinct of letter with white space; better defined than before; lasted through.

(2) *Letter A in "ATE."*

St. Succeeded in getting A more prominent than TE. TE kept coming in, and oscillated much in intensity. Attention ran from A to TE then back; seemed rhythmic. Caught self repeating A-T-E over and over.

St. Much the same as before. Noticed in addition movement of eyes when TE came. Tendency to repeat letters very distinct. Dropped into indistinctness but for no appreciable time.

K. First a somewhat indistinct image of letter A; then T a little more distinct; E rather vague. Then back to A and got a very clear image of it. Articulatory of T; E remained indistinct. Then tried to get whole word visually; A distinct and other not. At last dropped into mere articulation of A-T-E.

(3) *Letter A in "RELATE."*

St. Conspicuous thing was inability to get A alone for any length of time. RE was indistinct for awhile then was most distinct. L did not appear at all. A did not disappear completely at any time. Tendency to run over letters but not to speak word. After other letters came up distinctly, attention always ran back to A.

K. Very vague visual of space that word takes, letters indistinct. Started to articulate; word broken in this way into two parts REL-ATE. Visual came again and followed the division. Got R very distinctly, other two vaguely; same when went to last part. Visual on whole less distinct than motor.

These letter tests are in some respects the most interesting of the visual series, because they show the visual in connection with articulatory-motor elements, a combination rendered unavoidable by long association.

(1) The single letter appeared as a purely visual image, without tendency to articulate, hard to get and hold, and much subject to fluctuation and distortion.

(2) In the second test, St found the attention running from A which remained prominent to TE, and back again in the

rhythm set by the articulatory process. In the final test, K broke the word into two parts by articulation and then visualized it as broken, with the first letter in each part more prominent than the others. We have here a clear case of the visual following upon and being determined by the articulatory.

(3) It is to be noticed further that the A becomes clearer and can be held with less difficulty when articulated and placed in conjunction with the other letters. This latter process of reinforcement is probably the same as was found in the square series, where a slight complexity was necessary to give the attention play and also hold it within certain limits. The repeated articulation makes a direct and regular path back to the letter.

#### EXTENT AND SCHEMATISM OF THE INNER VISUAL FIELD.

The apparatus for experimenting upon this subject consisted of a black cardboard, two feet square, on which were pasted in regular arrangement five rows of five red spots, each an inch and a half in diameter. The subjects were not placed under time conditions, but were allowed to look at the board whenever they wished, and after closing the eyes, to continue as long as the image could be held easily. The introspection, as usual, was taken in full immediately. There is complete uniformity of results with all the subjects tested.

(1) When the effort is made to get an image of the whole figure, two indistinct rows come out, one on top, the other on the side. These consist merely of dark broad lines in which the individual spots are not defined. The rest of the board is confused.

(2) The easiest and most persistent arrangement of the whole board is that of two squares, an inner and outer, with the center left out. This again consists merely of the dark lines which sometimes look like indefinite beaded lines. If the attempt is made to bring out any particular spot, the squares break up and disappear.

(3) If attention is given to the central spot, isolated from the rest, it is hard to get, comes out only in flashes, and does not keep its position, but tends to stand out from the board or run over it.

(4) If the top row is taken and followed across, the spots can be brought out successively but only momentarily. The end ones come out most clearly and remain longest, the inner ones darken and are harder to get. The row tends after a time to go into a jumble, but can be rearranged by stopping and catching the end spots. Order is kept by counting. Dark lines run down from each spot to represent the vertical rows.

(5) The maximum number of spots that can be held clearly

at one time is five. These arrange themselves in certain geometrical figures, as follows : (a) Four corner spots of outer square with vague center in the arrangement of diagonals. (b) Center and middle outside ones in the arrangement of horizontal and vertical crossed lines. (c) Center and corners of inner square. (d) Center and middle ones of inner square.

Two of the facts noted suggest a resemblance of the inner field to the range of attention with minimum time of perception. These are the geometrical arrangement of five spots, and the prominence of the ends when a row is taken. There is, however, an important difference in the matter of extent, in that the attention during its single pulse does not select the number perceived from a larger number. Like minimum external perception, again, a basis is laid in its one act for the perception of more complex images. The most important factor, probably, in the constitution of the inner visual field, is the dropping of certain parts into obscurity, without losing them as a setting for the parts that remain distinct. Introspection fails to disclose fully just what takes place. There is a vague "feeling of something there," together with a certainty of what it is, and of the ability to recover it if wanted. It is probable that most of the setting can reduce itself to a highly abstract, even geometrical, schema of directions and positions. When attention was given to the red spot in a corner of the board, it could be held firmly as to position by reason of the right angle formed by the edges, so that the appearance of the rest of the card could be easily studied. For one subject, there were two broad lines leading off at right angles from the spot held, representing the two outside rows of spots, while all the remaining spots formed an undifferentiated mass, characterized only by a slightly brighter illumination. For another subject, a better visualizer, the outside lines leading to the spot were clear, and also the two sides of the inner square parallel to these, the broad gray lines being the nearest approach to distinctness.

Binet gives an interesting discussion<sup>1</sup> of the visual memory of chess players, and their visualization during blindfold games. One of the questions which he addressed to the players concerned the extent of the image : "Do you represent to yourself the chess board and its pieces all together simultaneously, or only by parts which appear to you in a successive manner?" A single player, Tarrasch, affirms that he visualizes the board entire, and that that total visualization is necessary. But when he adds that he represents a small board in order that the mental regard may be able to pass more easily from

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<sup>1</sup> *Psychologie des Grands Calculateurs*, 1894. p. 28 ff.

one space to another, it is very evident says Binet, that his visualization is successive. Another player, Schallop, says, "There are occasions when I see the board entire, but there are also others when I see clearly only that part of the board on which the combat is actually going on." "That last part of the response," says Binet, "states the opinion of the majority of the players. It is a rule, one may say, that players represent only a part of the board."

In a chapter on concrete and abstract visual memory,<sup>1</sup> there is presented an examination of the kind of image held in blindfold play. With some, he found visualization almost entirely lacking, the play taking the form of a mathematical calculation. With others who were in the habit of visualizing the board and pieces, all unnecessary details were dropped out and the image made as abstract as possible. One did not even distinguish the pieces except by a sense of their value. Generally, a detailed visualization of the board seemed to mark the amateur and was never characteristic of a proficient practiced player.

#### MOTOR AND MOTION IMAGES.

The motor element in mental imagery was first adequately emphasized by Stricker, in two treatises. In the former,<sup>2</sup> he sets forth in detail observations made on himself relative to the various elements in the word, and deals especially with the fact of initiated but suppressed articulation in his word thinking. In the second,<sup>3</sup> he carries his theory of motor function much further and makes it the fundamental element in both perception and memory of every kind of movement, and the basis of a doctrine of causality. A quotation from the latter work will illustrate his point of view, and also present his contribution to the motor side of mental imagery.

"My recollections of the movements of all lifeless objects are for the most part knitted with feelings in the eye muscles. If I wish to represent to myself the flight of clouds, I must connect with the image of the clouds, the feeling, as if the eyes would follow them. If I try to suppress this feeling, immediately the idea of the motion stops, and the clouds appear as if bound fast. Just as with the image of the clouds, so it is with the memory of the flight of birds, of rising smoke, of the passing vehicle."<sup>4</sup> So Stricker found with the images of all moving objects, as the railroad train, wheels and other rotating objects, and even the hypothetical motions of molecules and atoms. In other chapters, he treats the muscle

<sup>1</sup> p. 284 ff.

<sup>2</sup> Studien über die Sprachvorstellungen, 1880.

<sup>3</sup> Studien über die Bewegungsvorstellungen, 1882.

<sup>4</sup> p. 17.

feelings which accompany the perception and representation of movements of living objects and of parts of his own body. Other writers on the motor side of mental imagery have limited themselves entirely, so far as could be ascertained, to the articulatory impulses in word thinking.

The experience of the writer coincides exactly with that of Stricker, so far as eye movements are concerned, and so does that of two of the subjects examined. A few tests are presented in the following.

(1) *Heavy line in long parallelogram to be seen moving.*

St. Had some trouble in starting it; sort of mass movement not clearly outlined. Moved rhythmically with eye movement which was very distinct. Continuous.

K. Right end was normal size, part to left of spot was smaller. Then spot took up position at corresponding place on other end, then back; repeated three or four times. Lines were very vague. Left end distorted further by becoming tube, this did not extend to rest of it. No eye movement noticed.

(2) *Figure of pendulum ready to swing.*

St. Eye movement clear. Seemed to feel a distinct accent on start of swing.

K. Felt when saw it that it would be impossible to avoid having it move. First part clear was bob and line which seemed decidedly behind it; then filled in rest of pendulum. Did not move as was expected but seemed held there. At last got it to the other side but only by going to the suspension point and coming down. Moved it back to its original position in the same way. Had queer feeling when saw it hanging there and not going.

(3) *Circle with ball to move around circumference.*

St. Felt eye movement distinctly. Image came up readily but somewhat distorted. Ball moved around about every two seconds. Remained fairly distinct; circle clear where ball was.

K. Imaged clearly about one-fourth of circumference on each side. Then clear image of ball and completed the circle. Came back to ball and it went up to left a little; circle bulged at that point and ball stopped; whole circle fairly distinct. Then vague spell of about one second before call.

Sd. ("Swinging pendulum" called.) Got large pendulum in motion but not clearly in motion at all points; more pulled off to left. Seen as clearly as in actuality. Tendency strong to swing head in time. Half way through attention was caught by retinal light, so lost pendulum but still kept time to it; behaved as if knew pendulum was swinging behind rose colored curtain.

The figures were drawn so as to show clearly the part to be seen moving and also the course of the movement, and the subject was instructed beforehand that the movement was to be produced in the image. The results, while somewhat diverse, bear clearly upon the same point, the importance of eye movements for motion images. With St, the feeling in the eye muscles was clear and continuous in all the trials. With K, no eye movement was perceptible, but he was also unable to

get any movement in the images. Another difference between the two subjects suggests a relation between the motor and visual constituents of the image. St found in the first test that while the movement was clear and regular, the outlines of the figure were more or less indistinct and describes it as a kind of mass movement. He has nothing to say about the visual image in the second test, and in the third speaks of the circle as clear only where the ball happened to be in the course of its movement. The record for K shows primarily the clearness and profusion of his visualization, and again that every attempt to produce a movement resulted in a mere distortion of the figure. This would seem to indicate that the inner visual field must be constricted, and the play of attention over the parts, necessary in holding a figure of any complexity, be eliminated in order to produce a motion image. In nearly all cases the play of attention is accompanied by slight eye movements which would, of course, conflict with the movement necessary to produce the motion.

Motion images may also depend upon the activity of other parts of the body with which they have become closely associated by habit. When the writer sits by his window rocking, the vertical stick in the sash frame makes a dark line moving back and forth on the gray background of the wall opposite. If the rocking is stopped and the attempt made to image the motion with eyes closed, it is found to be impossible however much eye movement is used. When the rocking is resumed, eyes still closed, it is impossible to image the line other than as moving rhythmically with the movement of the chair.

It is admittedly a matter of the greatest difficulty, in the present state of knowledge, to estimate the extent to which motor functions influence other conscious factors. Even the study of completed action, as the counterpart of the idea, brings up problems of bewildering complexity, and the consideration of impulses, vague tendencies to movement, residual influences of past actions, etc., falls within the region of the almost entirely unknown. As to the significance of these processes, however, there can be little doubt. The image, on account of its exceedingly fleeting nature, may be taken as an index sufficiently delicate to measure the influence of some of these factors, when it can be found both in and out of connection with them. Galton describes the results obtained by the method of a certain teacher of drawing. "He trained his pupils with extraordinary success, beginning with the simplest figures. They were made to study the models thoroughly before they tried to draw them from memory. One favorite expedient was to associate the sight memory with the muscular memory, by making his pupils follow at a distance the outlines of the figures with a

pencil held in their hands. After three or four months practice, their visual memory became greatly strengthened. They had no difficulty in summoning images at will, in holding them steady, and in drawing them. Their copies were executed with marvellous fidelity, as attested by a commission of the Institute, appointed in 1852, to inquire into the matter, of which the eminent painter, Horace Vernet, was a member." He also cites the case of a young Indian who was seen "tracing the outline of a print from the *Illustrated News* very carefully with the point of his knife. The reason he gave for this odd manœuver was that he would remember the better how to carve it when he returned home."<sup>1</sup> The following is clearly a case of the same kind.

In the course of the experiments with words and letters, the writer noticed the extreme difficulty he encountered in holding a printed letter or word as compared with those he had written. When the printed letter was visualized, it would come out in a flash and disappear immediately. The parts were distinct and normal during the instant but if held tended strongly to become distorted. The letter always seemed unfamiliar, and there was the repeated experience of giving great effort to the development of small details in order to complete the image. When the printed word was visualized, the letters were always indefinite and schematic, and seemed merely to follow in the trail of the more prominent articulatory process. Words of more than five letters required not less than two distinct acts of visualization which were lacking in any kind of continuity.

On the other hand, it was quite easy to obtain a clearly outlined and fairly continuous image of the letter or word as customarily written. In the case of the letter, the attention played over the image, bringing out one part after another in the order and same time rate, and with the same continuity as in the writing process. In the same way words could be visualized with great distinctness, and if not too long, held with some facility without the help of articulation. If the latter process was allowed to come in, whole lines could be run over easily and continuously, each word being given its appropriate place. The images were entirely, so far as introspection could ascertain, of a visual nature, and not accompanied by the slightest tendency to reproduce the writing movement.

A possible explanation of these facts is that tracing the figures merely gives greater familiarity by bringing all of the details to attention, and fixing a certain association series. Or, again, there may be a persistent motor tendency which directly reinforces the visual imagery. The two explanations may not

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<sup>1</sup> *Inquiries into Human Faculty*, p. 105-6.



be so very far apart, because of the known motor element in attention, and the probable motor basis for continuity in association. The importance of rhythm will be treated in another connection.

#### AUDITORY IMAGES.

No department of psychological literature contains conclusions more divergent and contradictory than that dealing with auditory images. This is apparently due to two facts. First, the observations recorded are almost purely of an individual nature, and seldom made under strict conditions of experiment and analysis. Again, the investigations have been limited almost entirely to word thinking, a choice of materials that must be considered peculiarly unfortunate, because both association and apperception have established in the word an almost unanalyzable fusion of elements. The consequence is that when an investigator finds the motor element predominating or deficient in his word thinking, he puts this forward as indicating the absence or presence of auditory images. Thus Stricker<sup>1</sup> and Dodge<sup>2</sup> find the sound of the word entirely lacking, and in its place merely a movement of the articulatory organs. Egger,<sup>3</sup> on the other hand, finds the sound of the word predominating, and concludes that the auditory image is independent of motor factors. There is no intention here to discredit these important investigations, but merely to ask the question if these processes would repeat themselves in the representation of sounds not so inextricably woven into an established complex of relations. The question is, of course, too extensive to demand full consideration in studies whose primary purpose is the investigation of words, or even one of this kind. The peculiar value of Baldwin's contribution<sup>4</sup> is that he points out the fact that the kind of word thinking has a deeper basis than a general fixed tendency, and depends in large measure upon associations incident to training, which may vary considerably for different departments within the same individual.

The method in our experiments, a few of which are presented here, was to give the "ready" signal two seconds before, and the call word at the beginning of the ten seconds interval.

##### (1) *Tuning fork.*

St. Felt tension in tongue but could not really get sound. Had sort of humming located in mouth, fairly continuous. No visual image of fork. No kind of outside setting.

K. Got sound image a little preceding visual. Visualized fork on

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<sup>1</sup> Studien über die Sprachvorstellungen, 1880.

<sup>2</sup> Die Motorischen Wortvorstellungen, 1896.

<sup>3</sup> La parole interieure, 1881.

<sup>4</sup> Internal Speech and Song; Phil. Rev., II, p. 385.

box. Double image continued through. Did not notice movement of throat muscles. No change in breathing noticed.

Sd. Doubted if he got genuine auditory image. Visualized fork in laboratory room. Repeated "pong" a number of times. Attempt to make sound image kept up to end of period. Probably no external sounds entered in as they failed to fit. Fork noticed was about an octave below middle C.

### (2) *Two tuning forks with beats.*

St. Visual image of two forks. Oscillation of attention between forks that really seemed external and the humming in head. Beats were only rhythm put in by emphasis in humming. Visual image had no setting, seemed just in front in air. It fluctuated considerably.

K. Visual image not so prominent. Got sound first, then visualized two forks vaguely. Beat very distinct; tendency to follow it with hand, also in vocal organs. Tendency to visualize beat as motion in air between forks with vague waves coinciding and opposing. Had been somewhat in habit of doing this.

Sd. Got it pretty well and held clearly. Visualization of forks on boxes, but not so distinct as before. Less vocal than before. First mostly auditory and toward end almost entirely motor. Beats not perfectly regular, two or three per second. Persistence seemed to depend on its being motor.

### (3) *Slowly dripping water.*

St. No visual imagery. Felt distinct movement in throat. Rhythm intervals about a second long. Word "drop" was repeated with the rhythm.

K. First visual image of faucet and rather vaguely of basin. Sound image very distinct. Did not follow drop down but could feel it when it struck; some motor element in this. Eye followed waves on surface of basin. Did not notice any movement in throat. Drops came every second or so.

Sd. First indistinct visualization of water dripping. Then became very definite with visualization of leaky radiator (memory). Tendency to imitate by use of word "drip" at regular intervals. Rather more motor than auditory on the whole; continuous. At end all had degenerated into mere use of word.

### (4) *Quickly dripping water.*

St. Seemed as if in room and sound outside, but no visual image of room or water. Sound was not "drop," realized that it was too slow; was a kind of "ta" repeated rapidly. Chief part of the whole complex was movement in throat. Continuous on account of rhythm.

K. At first a clear visual image of string of drops close together with very vague visual of faucet and basin. Then sound image as before only more rapid. Sound did not fit the string of drops so did not hold it. Fluctuation between sound and visual image trying to get fit. Slight eye movement in following the drops down. Got sound image when reached bottom of string.

Sd. Partial visualization at first. Obscure "drip, drip" said rapidly. A few associated images with it. Too much engaged in introspection and image disappeared.

### (5) *Waterfall.*

St. Visual image of waterfall and water falling over. Movement of throat muscles more in background and deeper. Some holding of

breath. Both auditory and visual pretty continuous. No tendency to use roar of street car passing outside.

K. Visual (memory) of waterfall. Motor element in following water down. Then got sound down below. At last got whole thing together—fall, basin, spray and sound. Auditory fairly constant.

Sd. Visual image more prominent than auditory. Something of auditory nature but should hesitate to call it an image. At one stage tendency to fit sound of wind outside to waterfall but given up. Whole thing weak. No motor side. Last two seconds nothing but more or less distinct memory images.

#### (6) *Ticking of watch.*

St. Felt clear movement of muscles. Began too slow for watch, more like clock, so forced a more rapid movement. Then came visual image of watch just out in front. Repeated word "tick." Continuous.

K. Sound image first, then visual of operator's watch. Visual constant, sound not. Motor element in sound in marking rhythm; also used word "tick." In last part was following out details of visual.

Sd. Some tendency to imitate but less than with water. One instant tried to get operator's watch, then tried to get ticking in purely auditory way. It came almost pure but slipped away very quickly each time. Came three or four times. No definite picture of watch. Ticking very rapid.

#### (7) *Whistling of wind.*

St. Seemed in roof of mouth. No tendency to use outside sounds. Sound was of whistling around corner of house but no visualization of house.

K. Sound preceded vague visual, localized just outside. Visualized wind as streaks in the air going around eaves; followed motion with eye. Strong wheezy whistle. No throat movement.

Sr. Something of a memory image. Fairly easy to get but hard to hold. Came and went several times; toward last seemed to come in quick gusts. Attended by visualization of corner of house and distinct tension in throat.

(1) The fact of primary importance ascertained from this series is that we are dealing with a vastly more complicated set of conditions than in any of the experiments previously considered. Images of a visual character are possessed of a certain degree of independence, and the conditions of their maintenance are chiefly, for introspection at least, to be found within themselves. Again, motor images when taken in isolation, merely require a partial repetition of the original movement or impulse to that movement. But apparently in the case of auditory images, the conditions both of obtaining and holding them have to be brought in from outside. In other words, the study of auditory images is chiefly one of association, both of ideas and sense elements. The auditory element seems to be partially distinguishable from the associative complex focused upon it, as shown in those cases where the situation was held continuously and the sound came and went. In other cases, the situation was all that could be obtained, and a word was used to fill the

place of the image, as with the dripping of water and ticking of watch.

(2) The most important incentive to the production of sound images is, without doubt, movement of the organs of articulation, especially the throat muscles. The series of tensions and positions used in actually producing the sound stand so closely connected with the image that the latter often seems to come directly from them and to be heard only inside. If they are lacking, on the other hand, in many cases mental audition is impossible. When, for example, the writer wishes to recall a phrase of music that he has heard, it can be done only after the tensions fixing the tone relations are definitely under control, which sometimes requires several days of trial. Another motor element, upon which the production of sound images depends, is rhythm. It is a kind of solid skeleton, so to speak, which supports the soft tissues. It is doubtful if a continuous, unvarying sound image can exist at all. On the other hand, one that comes at regular intervals can be produced very easily.

(3) An interesting distinction comes out in the series between two of the subjects. St really has much better auditory images than K, and is strongly motor, while K is strongly visual. When St in his introspection, analyzed his associative complexes and found the motor elements so predominating, he became very doubtful if he got any sound image at all. K, who visualized to the extent of seeing the sound waves between the forks, and the streaks of wind around the eaves, and felt no tension in the throat, was quite sure that he got distinct sound images. This raises the question as to the comparative sufficiency of the two kinds of complexes. The visualist probably proceeds more from the standpoint of the object and the enumeration of qualities. When the object stands out complete except for the sound, and the whole situation is arranged so as to point to it, it may seem present as a matter of course whether it actually appears or not, and may seem as clearly distinguishable as any of the other qualities. It is similar to the case of filling in the blind spot in the field of vision. On the other hand, the subject who visualizes little, and in whom motor elements predominate, must proceed primarily from the standpoint of these elements, and when he attempts to analyze the association and distinguish the auditory image from the movements connected with it, the image has nothing to support it.

#### DERMAL, GUSTATORY AND OLFACTORY IMAGES.

Lay gives a list of ten types of mental imagery observed in himself.<sup>1</sup> Besides visual and auditory, he finds *tactile*, of which

<sup>1</sup>Mental Imagery; Psych. Rev. Mon. Sup., VII, p. 36 ff.

he says, "This seems to me as clear and strong as any other, occasionally stronger;" *gustatory*, of which he says, "Sour and sweet are the only tastes I revive quite clearly, the others being three parts visualization and olfactory;" *olfactory*, "These are in my own case extremely numerous;" *thermal*, "The percentage of my own thermal imagery is only 2% and contains such imageries as 'warm feet,' 'cold nose,' etc.;" *motor; imagery of pain*, "I can imagine pain, *e. g.*, that of a stubbed toe, a cut, or a pounded finger;" *organic*, such as hunger, thirst, etc.; and imagery of *emotions*. His method was to make numerous association series, classify and take percentages. The faultiness of the method is evident after a direct examination of the images. Our subjects failed to manifest such an elaborate equipment, as the following series will show.

### I. (1) *Feeling of plush.*

St. Got visual image of hand passing over plush. Thought he got plush feel for a moment. Decided "creepy" feeling, due to unpleasantness continued throughout.

K. Visual image of blue plush on back of chair followed by visual and motor of moving hand. Plush feel on fingers was very clear but did not last. Slight pleasantness.

Sr. Could not get it but saw rose colored plush very distinctly. No incipient movements noticed. Effort to get dermal distinct. Visual continuous.

### (2) *Clammy hand.*

St. Visual of hand. Clear clammy feel which directly went over to "creepy" feeling. Some shudder. Noticed no tendency to speak word, but distinct tendency to express repulsiveness.

K. Fairly distinct visual of hand clasped in own, then tactual and temperature combined, latter distinct. Motor of grip. Word not present. No affective quality noticed.

Sr. Clear visual of hand. No dermal. Repeated word over and over, and coupled with it feeling of repulsiveness.

### (3) *Hot water.*

St. Had fair visual of hand in water. Then of wetness and temperature, not very clear. No tendency to use word.

K. Visualized hand and hot water. Tactual and temperature of water localized in fingers quite clear (mem. from experiment). Organic and affective elements present.

### (4) *Plunge into cold water.*

St. Distinct visual image of self going into bath tub, followed by sort of shudder. This kept repeating itself.

K. Visual (mem.) of cold shower bath. Strong organic reaction of chill. Then visual of self jumping into cold river. Saw splashing of water. Repetition several times of organic shiver.

Sr. Less visual setting than usual; seemed to be closing eyes to jump into water. Had all the chilly, spasmodic, shrinking feeling. This was momentary but kept repeating itself (about six times).

## II. (1) *Salt.*

St. Flow of saliva seemed to increase. Felt a certain dryness in throat which usually comes when subject tastes salt.

K. Visual, tactual and motor together of mouth, moving tongue and contact with salt. Then for a moment seemed to get taste of salt localized on tongue.

(2) *Bitter.*

St. Seemed to feel some puckering in mouth and setting of muscles as in real bitter. Attention directed to mouth.

K. Nothing very definite. Motor and tactual images of moving tongue. Then vague visual of position of tongue and something on back of it. Fairly clear organic reaction to bitter.

(3) *Sweet.*

St. Nothing but moistening of tongue.

K. Vague visual image of tongue and mouth and vague motor of moving tongue. Then for instant visual (mem.) image of sugar. Then seemed to get a very indistinct taste image of sugar, but tactual and motor very prominent elements. No tendency to pronounce word. Not certain that he did not visualize word.

(4) *Sour.*

St. Seemed to be some change in mouth but could not distinguish what it was.

K. Visual of jug of vinegar (mem). Seemed first to smell it. Then complex of visual and motor with vague feeling of sour on back of tongue.

III. (1) *Ammonia.*

St. First trial, could get nothing. Second trial, thinks there was some kind of tension or irritation in nostrils. No associated images of any kind.

Sd. Nothing that could be called image. Some feeling in nostrils. Visual of bottle of smelling salts. Word seemed more or less present to consciousness. Inhaled. Feeling lasted only a second or two.

K. Nothing very definite. At first, a blank period of trying to recall odor. Inhaled as in act of smelling. Vague visual image of bottle with ammonia label. At last, seemed to get a vague feel of ammonia located in nostrils.

(2) *Alcohol.*

St. Visual (mem.) image of bottle, seemed right under nose. Could feel no sensation in nostrils. Breath a little irregular.

Sd. Visual of laboratory and place where alcohol is kept. Recollection of occasions when smelled it. Whole rather vague. Seemed at last to get some faint whiffs.

K. First, distinct visual of big laboratory bottle with label on it. Motor of breathing. Finally seemed to get some faint recognition of odor image. Not very distinct. Slight feel of temperature, "cool smell."

It is evident that here we have the association process, discussed under auditory images, going a step further. The existence of dermal images in normal persons is extremely doubtful, and the non-existence of taste and smell images practically certain. There never seems to be anything more than what may be called the *intent*. There is a focusing of the associative complex and a special emphasis of the distinctive factors that have attended the sense experience. Frequently a word is

used to fill the gap and satisfy the situation, and there is always a feeling of certainty of being able to recognize the sense experience if repeated. The words referring to these departments, that come out in the association series, are probably based upon actual sense experiences, and when recalled have nothing more than a certain associative value. This, however, is quite sufficient in everyday life, and perhaps the limitation is a necessary one, as a clear taste or smell image would undoubtedly be included in the list of illusions. We can hardly admit dream images as evidence of the actual presence of taste and smell images because of their general hallucinatory character and the uncritical way in which they are obtained.

#### THE DIRECTION OF IMAGES.

Some of the subjects were tested as to the directions in which the images appeared, and the writer has for a long time made careful observation of this characteristic in his own images. It was found that the images of objects shown to the subjects invariably seemed in the same directions as the objects themselves. If an object was shown and the subject wheeled so that it was back of him, he seemed to be looking at it through the back of his head. The same was true of familiar objects about the room. The actual directions were in every case preserved.

Concerning objects not actually present, as houses, rooms, etc., in the vicinity and elsewhere, the following results came out. (1) When the name of an object lying in a definitely known direction is called, as a familiar building in the city, if it has ever been seen from a point on the line of direction from it to the subject, this direction is preserved, the aspect perceptible from that point appearing and seeming to be observed directly from where the subject actually is. For example, if he is sitting in the University laboratory and is told to image the City Hall, there is first a distinct straining in that direction, front, side, or back, according to his position, and then he sees the building directly from where he is and that side of it visible from the street leading toward the University. (2) If the object has not been seen from a point on the line of direction, a double process takes place. There is first a definite feeling of the direction of a point from which it has been seen, accompanied by the appropriate setting of images, frequently with a vague image of the self in that position. Then there is a change in the feeling of direction to that of the object from that point. If the subject is in the laboratory and is told to image the front of the building, there is first a strain in the direction of the street, and then just as definite a strain back.

If every step in the experiment is noticed carefully, it will be seen that there is a rapidly recurring fluctuation from the one sense of direction with its set of images to the other. This is perhaps the reason why images of such objects are much more difficult to hold than those described in the first case. (3) With objects that have lost the particular setting that gives a definite memory quality, by reason of having been seen in many settings, the sense of direction with some is indeterminate, and with others varies in individual cases.

Here, of course, the motor element is of paramount importance. Introspection finds nothing more as a basis for the sense of direction than certain combinations of strains. When an object is localized in front, the eyes are kept in that direction, and there is a distinct release of tension; when localized back of the head, there is a distinct increase of tension in the antagonists; when localized on the side, the eye is drawn partly in that direction. Combined with these eye movements are the minutely graded contractions of head, neck, and even abdominal muscles.

#### CONCLUSION.

While our data are insufficient for any very definite or far reaching conclusions, the work seems to throw light upon one or two facts respecting the behavior of images. These are, (a) that the factors which keep visual images in clear consciousness are their own internal organization combined closely with motor elements; (b) that auditory images appear only in connection with an organized associative situation, in which motor elements usually play a predominant part; (c) that images from other sense departments also require such a situation which is, in most cases, all that appears, so that the real existence of these images is doubtful.

There are certain general questions bearing upon the work, whose consideration is necessarily of the most unsatisfactory kind. One of these is whether the images obtained under introspective conditions are the same as the normal working images of everyday life. It may be that voluntary recall and control, and the process of analytical examination produce a result varying considerably from the normal sequence of images. But since introspection is the only means of approaching the images, the question must necessarily remain unanswered.

Another general consideration is that of the means by which a subject is able to criticise his images. In at least two cases, parts of the image were found to be disparate, as when with St the ticking of the watch was too slow, and with K the sound did not fit the dripping water. Apparently there is a standard outside the image itself by which it is tested, and we have to



deal with a situation which is not merely a self-adjusting memory complex. The problem is one which falls within the discussion of recognition and not of images proper.